CAAP Quarterly Report

Date of Report: 1/4/2021

Prepared for: *U.S. DOT Pipeline and Hazardous Materials Safety Administration*

Contract Number: 693JK31950006CAAP

Project Title:
An autonomous UAS inspection platform for high-efficiency 3D pipeline/route modeling, change-detection, and gas leak detection-localization

Prepared by: Zhigang Shen
Contact Information:
Associate Professor
The Durham School of Architectural Engineering and Construction
College of Engineering
University of Nebraska–Lincoln
113 Nebraska Hall, P.O. Box 880500
900 N. 16th Street, Lincoln, NE 68588-0500
402-472-9470 | shen@unl.edu| biim.unl.edu

For quarterly period ending: **12/31/2020**

Business and Activity Section

(a) Contract Activity

Contract modifications:

No contract modification is expected at this point.

Discussion about materials purchased:

DJI Mavic Air UAV was purchased to conduct experimental flights to verify the developed path panning algorithms. The cost of the UAV was $1,082.

(b) Cost share activity

The PI dedicated 0.2 FTE in this quarter to the project.

(c) Status Update of the Quarter's Activities

Task 1: Develop a prototype of pipeline/tank inspection data management and the integration module (PIDMIM). (100% completion)

Task 2. Develop the quality-based 3D coverage path planning (CPP) algorithm.

~~Subtask 2.1.~~ ~~Identify and investigate the appropriate parameters and their value ranges to balance the UAS inspection efficiency and photogrammetry model quality. Identify appropriate optimization algorithms for pipeline/tank 3D coverage path planning (CPP). (100% completion)~~

Subtask 2.2. Implement and test the developed 3D CPP algorithm through simulations and indoor/outdoor flight tests. (~~50%~~ 85% completion).

A new quality based UAS path planning algorithm was developed and tested through simulations. Outdoor tests to be arranged contingent on the weather conditions. A draft journal paper is ready for submission to report the outcomes of the algorithm.

In this paper, we reported a topology-aware coverage algorithm that leverages the topology of the scene geometry for the stereo view selection in a parallel fashion.

Based on the coverage model, our optimization simultaneously optimizes the camera views as well as the best stereo pairs for 3D reconstruction of each mesh surface. We demonstrate the versatility and effectiveness of the proposed method on four selected synthetic scenes using different input geometries (e.g. nadir flight and the 2.5D). The results show that our method outperforms the state-of-art in different configurations in terms of the reconstruction quality and the optimization efficiency. The following two figures are from the paper and are intended to provide an illustration of the developed method.

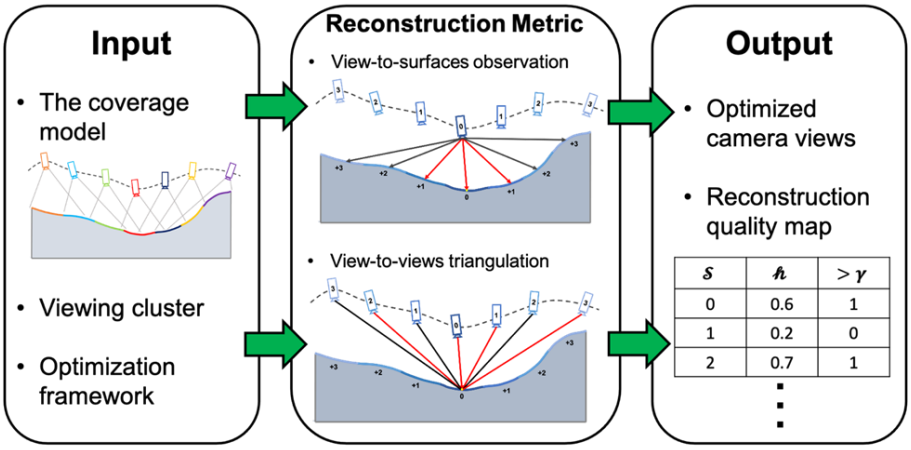

Figure 1. The schematics of the methodology of the develop path planning algorithm

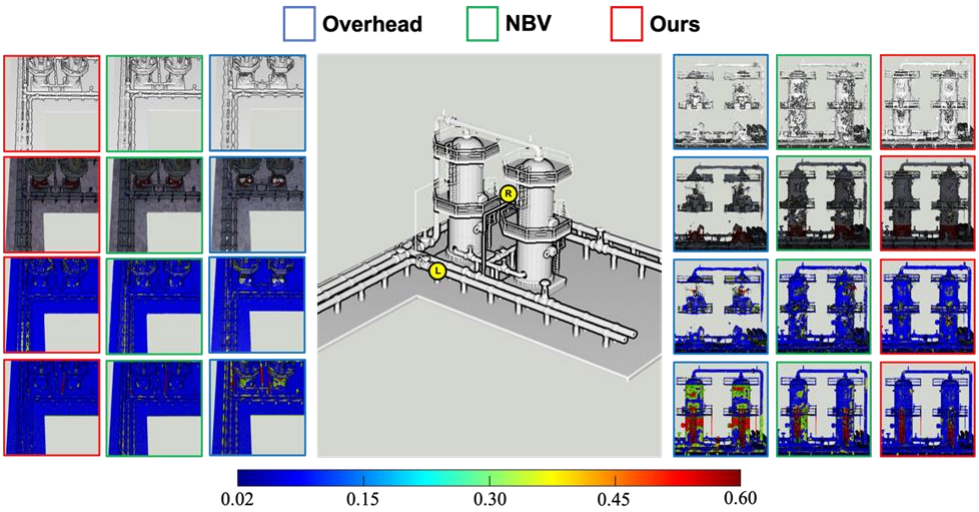

Figure 2. Quality evaluation of the algorithm using an oil/natural gas facility as an example

Task 3. Develop a 3D profile change identification and quantification (PCIQ) module

Subtask 3.1. Identify and evaluate the out-of-the-shelf photogrammetry software in terms of its capability and accuracy in processing a large inspection pipeline dataset and create demonstrative before-and-after 3D pipeline/route models.
(~~50%~~ 75% completion) No new activities in this quarter.

Subtask 3.2. Develop a 3D profile change identification and quantification (PCIQ) module to allow automatic before-and-after event comparisons of 3D models to identify the change locations and change quantities. The changes can include land movement, third-party excavation, pipe displacement, scour erosion, etc.
(0% completion) No new activities in this quarter.

(d) Scheduled work in the Next Quarter

The focuses of the Quarter 1 in the second year are Subtask 3.1 and 3.2 in Task 3.

References

W. Jing, J. Polden, W. Lin, and K. Shimada, "Sampling-based view planning for 3D visual coverage task with unmanned aerial vehicle," in *IEEE International Conference on Intelligent Robots and Systems*, 2016, vol. 2016-November, doi: 10.1109/IROS.2016.7759288.

A. Bircher *et al.*, "Structural inspection path planning via iterative viewpoint resampling with application to aerial robotics," in *Proceedings - IEEE International Conference on Robotics and Automation*, 2015, vol. 2015-June, no. June, doi: 10.1109/ICRA.2015.7140101.

[J. L. Schönberger, E. Zheng, J. M. Frahm, and M. Pollefeys, "Pixelwise view selection for unstructured multi-view stereo," in *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 2016, vol. 9907 LNCS, doi: 10.1007/978-3-319-46487-9_31.

[X. Fan, L. Zhang, B. Brown, and S. Rusinkiewicz, "Automated view and path planning for scalable multi-object 3D scanning," *ACM Trans. Graph.*, vol. 35, no. 6, 2016, doi: 10.1145/2980179.2980225.